DEGRADATION OF ACID-TREATED AND UNTREATED STEEL FURNACE SLAG AS AN OPEN GRADED BASE COURSE FOR CONCRETE PAVEMENT

MICHIGAN DEPARTMENT OF TRANSPORTATION

TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

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DEGRADATION OF ACID-TREATED AND UNTREATED STEEL FURNACE SLAG AS AN OPEN GRADED BASE COURSE FOR CONCRETE PAVEMENT

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A study of the durability of acid-treated steel furnace slag for use as an open graded base course for concrete pavements was conducted and reported in Ref. (1). This study concluded that coarse graded acid-treated steel furnace slag aggregates are more susceptible to degradation than are natural and blast furnace slag aggregates of comparable gradation, but that the difference was not great enough to warrant restricting its use without further study. The report recommended that if steel furnace slag is used for open graded base construction, such installations should be considered experimental and their performance monitored. The report also recommended that, in order to obtain maximum durability, steel furnace slag should meet a loss-by-washing content of 0 to 3 percent.

On review of Ref. (1), the Levy Slag Co. indicated that steel furnace slag should be more durable when untreated than when acid-treated and requested that another study be conducted to evaluate untreated steel furnace slag. This report summarizes the durability properties measured for acid-treated and untreated steel furnace slag, blast furnace slag, and natural aggregates.

Testing Program

The results of the study reported in Ref. (1) are included in this report with test results of untreated slag samples submitted by the Levy Slag Co. The samples received were clean aggregates of excellent appearance. Tests conducted on the untreated slag aggregates include Los Angeles (L.A.) abrasion, freeze-thaw durability, impact resistance, and swelling potential tests. The laboratory procedures for these tests are outlined in Ref. (1). The cyclic loading test, conducted for natural aggregate and treated slag aggregate, was not used in the study of untreated slag aggregates.

Results

Degradation test results for untreated steel furnace slag and the results previously reported in Ref. (1) are summarized in Table 1. Figure 1 indicates the gradation of the untreated slag before and after exposure to T-180 compactive effort. The untreated slag aggregates tested showed no swell potential. The previous study, Ref. (1), indicated that acid-treated steel furnace slag and natural aggregates also showed no swell potential.

With the exception of the T-180 compaction test, the laboratory evaluation indicated little difference in degradation of acid-treated and untreated slags.

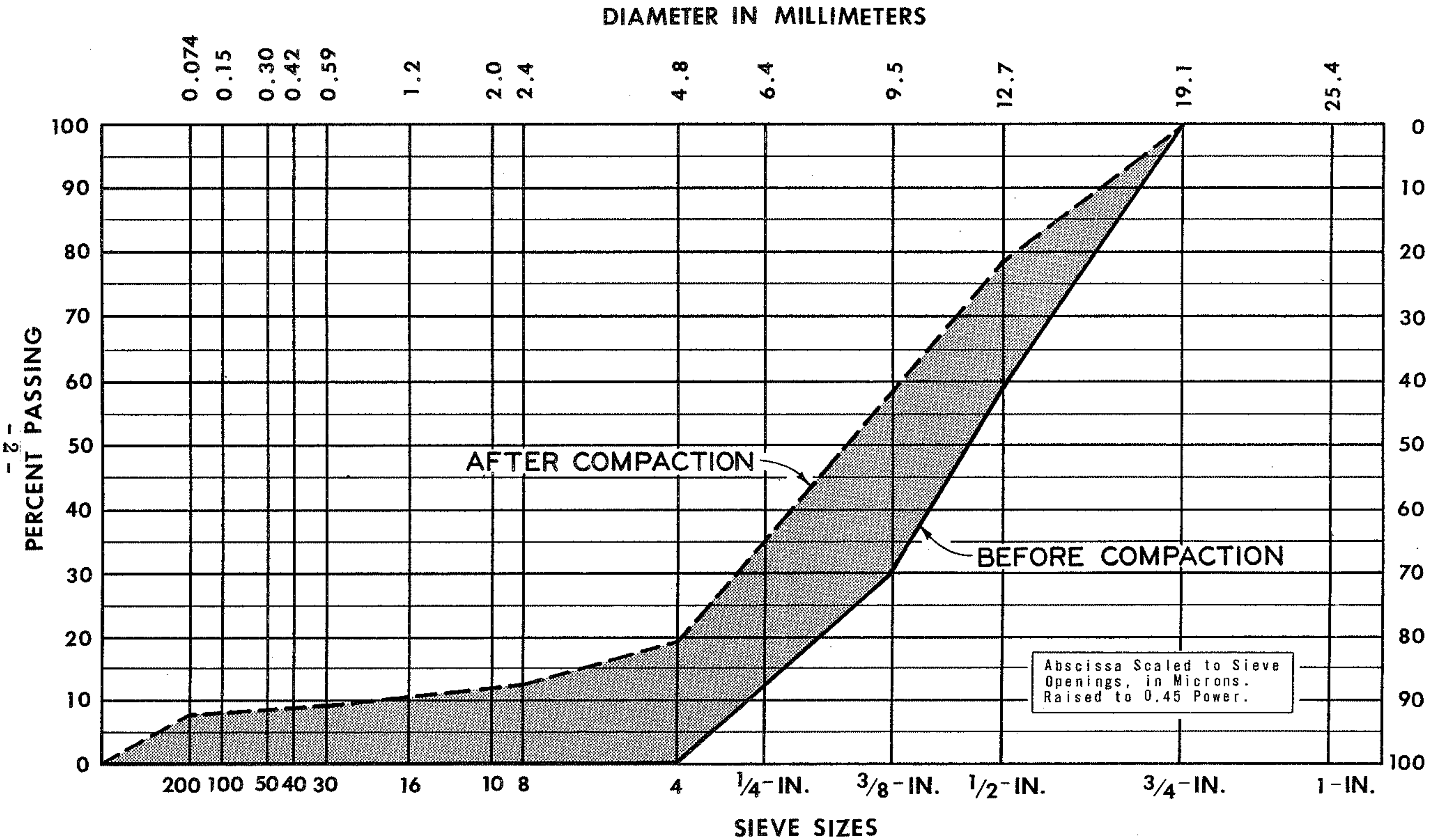

Figure 1. Grain size distribution before and after T-180 compaction of untreated steel furnace slag aggregate.

TABLE 1
AVERAGE DEGRADATION OF NATURAL AND SLAG AGGREGATES

Test	Average Percent Degradation			
	Natural Aggregates	Blast Furnace Slag Aggregates	Steel Furnace Slags	
			Acid-Treated Aggregates	Untreated Aggregates
L.A. abrasion	19.4	---	20.0	18.0
Freeze-thaw	3.1	3.0	8.5	10.2
Compaction	2.7	2.3	8.8	18.8
Repeated loading	0.2	0.1	1.0	--

Discussion

For this study, consideration is given only to aggregate durability and specifications required to ensure adequate aggregate durability. In this respect, proposed grading specifications allow a loss-by-washing of 0 to 3 percent, as recommended by Ref. (1), and to ensure that aggregates have the ability to resist mechanical breakdown, an L.A. abrasion value not to exceed 50.

The results summarized in Table 1 show that steel furnace slag has an L.A. abrasion of 20 or less which means it easily meets the proposed maximum allowable requirement of 50. Thus, both acid-treated and untreated steel furnace slags should have adequate durability to resist mechanical breakdown.

Table 1 also shows that steel furnace slags break down about three times more than natural aggregates as a result of laboratory freeze-thaw tests and from three to seven times as much as natural aggregates, based on laboratory compaction tests. These results indicate that steel furnace slag aggregates may not have the ability to resist mechanical breakdown under normal construction activity that natural aggregates have, even though L.A. abrasion test results indicate they do.

Although there may be reason to question how well L.A. abrasion values relate to resistance of aggregate to mechanical breakdown in the field, it is the only criterion that can be used to judge aggregate durability. The reason for this is that the relationship between aggregate breakdown during laboratory compaction tests and breakdown due to construction activities has never been established, and because the L.A. abrasion test is the only recognized test indicating aggregate resistance to mechanical breakdown.

Using a L.A. abrasion limit of 50, as is now proposed, appears to be too liberal, considering that the steel furnace slag and natural aggregates tested are all in the range of 20. It would appear as though a limit of 40 could be applied without restricting the use of steel furnace slag. The lower value may help limit the acceptance of materials that are too weak to function well as an open graded drainage course (OGDC) base.

While no freeze-thaw durability requirements are included in the proposed OGDC aggregate specifications, this study indicates that freeze-thaw cycles may be responsible for a higher level of breakdown of steel furnace slag aggregates than for natural aggregates. Considering the long term over which OGDC bases should be expected to perform, it seems reasonable that consideration be given to including aggregate freeze-thaw durability requirements for OGDC aggregates.

Conclusions

Laboratory tests performed during this study indicated that there was little difference in the degradation of non-acid-treated slag as compared with acid-treated except under the T-180 compaction effort where the untreated slag degraded more than the acid treated (18.8 vs. 8.8 percent passing the No. 4 sieve).

Assuming that the L.A. abrasion test accurately indicates aggregate durability, both acid-treated and untreated coarse graded steel furnace slag aggregates should be acceptable for use as OGDC aggregate. It was found, however, that the resistance to mechanical breakdown, as measured by the L.A. abrasion test and the laboratory compaction tests, do not agree. Thus, there is reason to question whether the L.A. abrasion test is a reliable indicator of the resistance of steel furnace slag coarse aggregates to mechanical breakdown. Test results also indicate that steel furnace slag coarse aggregates should be more susceptible to breakdown under freeze-thaw conditions than are natural coarse aggregates. However, the relevance of this difference is beyond the scope of this investigation.

Because steel furnace slag has good L.A. abrasion characteristics and because of the importance of having OGDC free of fines and fine aggregate, it is recommended that proposed OGDC specifications be modified so that the allowable percentage of wear, as determined by the Los Angeles Abrasion Machine, be decreased to a value of 40. It is also recommended that consideration be given to investigating freeze-thaw requirements for OGDC aggregates.

REFERENCE

1. Novak, E. C., Jr., "Degradation of Steel Furnace Slag as an Open Graded Base Course for Concrete Pavement," MDOT Research Report R-1188, February 1982.